

(19)



Europäisches Patentamt
European Patent Office
Office européen des brevets

(11)



EP 0 847 094 A2

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
10.06.1998 Bulletin 1998/24

(51) Int. Cl.⁶: H01L 51/20, H01L 33/00

(21) Application number: 97121325.1

(22) Date of filing: 04.12.1997

(84) Designated Contracting States:
AT BE CH DE DK ES FI FR GB GR IE IT LI LU MC
NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 04.12.1996 JP 337672/96
18.02.1997 JP 33580/97

(71) Applicant: Hitachi, Ltd.
Chiyoda-ku, Tokyo 101-0062 (JP)

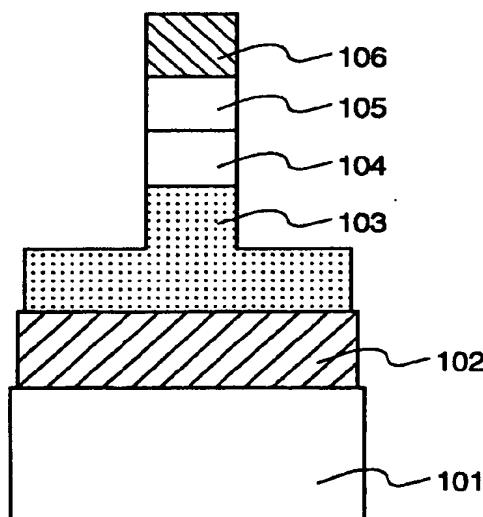
(72) Inventors:
• Nakayama, Takahiro
Minami-ku, Fukuoka-shi, Fukuoka 816 (JP)
• Kobayashi, Shinya
Mito-shi, Ibaraki 310 (JP)
• Shimada, Akira
Hitachi-shi, Ibaraki 319-12 (JP)

(74) Representative:
Beetz & Partner
Patentanwälte
Steinsdorfstrasse 10
80538 München (DE)

(54) Organic light emitting element and producing method thereof

(57) An organic light emitting element having a metal thin film (106; 404) on an upper surface of an organic thin film (105; 403A, 403B), is produced by mechanically cutting the metal thin film, using the cut metal thin film as a mask, and applying dry etching processing to the whole of the organic thin film (104, 105; 403A, 403B), and to a part of each in thin films on upper and lower surfaces of the organic thin film.

FIG. 1



EP 0 847 094 A2

Description

BACKGROUND INVENTION

The present invention relates to an organic light emitting element, especially to an organic light element used in optical instruments using an optical device such as a light source for display, an optical circuit, an optical switch, an optical array, an optical communication element, a head for optical recording, and so forth.

A resonator structure composed by sandwiching an organic light emitting thin film between two plane reflectors is used in a conventional electro-luminescence element which is disclosed, for example, in a paper titled "Investigations on Multicolor Display by Organic Luminescent Devices with Optical Microcavity Structure", by Nakayama, Tsunoda and Nagae, The Transaction of the Institute of Electronics, Information and Communication Engineers of Japan, J77-C-II, pp 437-443 (1994).

In an organic electro-luminescence element using a conventional micro-resonator structure, a means for confining light proceeding in the direction parallel to an organic electro-luminescence film is not provided, and light proceeding in that direction is lost. This problem occurs similarly in an ordinary type electro-luminescence element in which an existing micro-resonator structure is not used.

In the following, it will be explained why light proceeding in the direction parallel to an organic electro-luminescence film attenuates and it is lost.

At first, with reference to Fig. 11, a method of producing an organic light emitting element is explained.

Reference mark A indicates a substrate of the organic light emitting element, and a film B is formed by using a vapor deposition method with organic material. Regions to be masked from vapor deposition of organic material vaporized in a vapor deposition source D are masked by a metal mask C.

In a vapor deposition apparatus shown in Fig. 11, a very narrow gap which can be observed only by an optical microscope exists between an edge of the mask C and a surface of a growing organic thin film. The gap is generated by unevenness of the substrate A, a bend of the mask C, a roundish shape of the edge part in the mask C, etc.. Assuming that the width of the gap is 0.1 mm (= 100 μm), and the visual angle of the vapor deposition source D viewed from the edge part is 2 deg., the variation in a growing length of the thin film is 3.5 μm (= 100 $\mu\text{m} \times \tan(2 \text{ deg.})$).

That is, the thickness of the thin film changes from 100 % to 0 % in the interval of 3.5 μm .

Usually, since the thickness of an organic thin film such as one used for an organic light emitting element is about 0.1 μm , the ratio of the thickness of the organic thin film to the thickness changing interval is 1 / 35.

Therefore, if the thin film is formed by the vapor deposition method with the mask, the angle of the edge part in the thin film is 1.6 deg. (= $\arctan(1 / 35)$) as

shown in Fig. 12.

Light which enters the above-mentioned edge part of the thin film proceeds as it is repeatedly reflected by inner faces of the thin film as shown in Fig. 12, and attenuates, finally it is extinguished.

SUMMARY OF THE INVENTION

The first object of the present invention is to provide an organic emitting element wherein light proceeding in parallel to an organic thin film which has been ordinarily lost can be effectively utilized.

The second object is to provide an organic emitting element wherein a classical or quantum effect (correction of light emission enhancement due to the transition probability mechanism) brought by the confinement or resonance of light is applicable.

The third object is to provide a method of producing a highly pure organic thin film used in an organic emitting element. To attain the above objects, the present invention has the following features.

The first feature of the present invention is to provide an organic light emitting element including an organic thin film formed on a substrate, wherein a peripheral side face of the organic thin film has such a sectional shape that emitted light is reflected by the side surface.

The second feature is to provide an organic light emitting element including an organic thin film formed on a substrate, wherein the difference between a refraction index of the organic thin film and that of ambient substance outside the organic thin film is set to such that emitted light is confined in the organic thin film by a peripheral side face of the organic thin film.

The third feature is to provide an organic light emitting element including an organic thin film formed on a substrate, wherein a peripheral side surface of the organic thin film stands, in a range of 50 % - 90 % of the thickness of the organic thin film, perpendicular to the substrate.

The fourth feature is to provide an organic light emitting element, comprising multilayer of a translucent reflector film, a transparent electrode, a light emitting layer and a metal electrode, wherein an optical resonator is composed between the translucent reflector film and the metal electrode on the light emitting layer in the direction perpendicular to the organic light emitting layer, and a plurality of layer parts, each of the layer parts including the light emitting layer and the metal electrode, are separately arranged in a plane parallel to the substrate, respectively, and a distance between each pair of layer parts neighboring each other in the parts is larger than 1 / 4 of a wave length of light emitted in the light emitting element.

The fifth feature is to provide a method of producing an organic light emitting element including an organic thin film, the method comprising the steps of forming a metal thin film on the organic thin film, forming a mask

of a desired pattern by physically or mechanically removing parts of the metal thin film, and applying dry etching processing to the organic thin film with the mask.

The sixth feature is to provide an organic light emitting element having a resonator structure in the direction perpendicular to a substrate of the light emitting element, the resonator structure being composed by sandwiching an organic thin film in the light emitting element between two reflectors, the organic light emitting element comprising one of a line layer structure and a dot layer structure in the organic thin film and a part of thin films formed on the top face and bottom face of the organic thin film, in which line layers or dot layers are periodically arranged in parallel to the organic thin film, wherein each two line layers neighboring each other or each two dot layers neighboring each other have different material composition or material structure, and the period of the arrangement, which is represented by an optical length expressed as a geometrical length \times a refraction index in material of each layer, is substantially 1 / 4 of a wave length of light emitted in the organic thin film.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of an organic electroluminescence (light emitting) element having a micro-resonator structure, of which a peripheral side face is processed.

Fig. 2 is a diagram showing compositions of examples of material used in the organic thin film shown in Fig. 1.

Fig. 3 is a graph showing light transmission characteristics of a translucent reflection layer used in the organic electro-luminescence element.

Fig. 4 is a conceptual illustration for showing a cutting process for producing the organic electro-luminescence element according to the present invention.

Fig. 5 is a scanning tunneling microscope (STM) image of a sectional face of an organic electro-luminescence element which was cut by an cutting process.

Fig. 6 is a scanning electron microscope (SEM) image of a sectional face of an organic electro-luminescence element which was etched by an etching process.

Fig. 7 shows sectional views of light emitting elements of which depths formed by the etching process are different from each other, and diagrams (a), (b) and (c) in Fig. 7 show sectional views of the light emitting elements, which are etched in their depth to the bottom surface of the organic thin film, to the bottom surface of an ITO film, and to the bottom surface of a translucent reflection film, respectively.

Fig. 8 is a sectional view of an element in which by forming an insulation film on an organic light emitting element, further covering over the insulation film with a metal reflection film, the effect of light reflection by a

side face is further improved.

Figs. 9A and 9B shows sectional views of organic light emitting elements having a three-dimensional light confinement structure, and a two-dimensional light confinement structure, respectively.

Figs. 10A, 10B and 10C shows features of an optical device of an embodiment according to the present invention, and show a sectional view of the device, a composition of matrix type electrodes of the device, and a partially perspective diagram of the optical device, respectively.

Fig. 11 is a diagram conceptually showing a composition of an apparatus for forming an organic thin film.

Fig. 12 is an enlarged sectional view of the peripheral side part in an organic thin film.

Fig. 13 is an illustration for showing a composition of an organic light emitting element having a micro-resonator structure wherein a light emitting layer has a structure of a periodically arranged line layer pattern.

Fig. 14 is an illustration for explaining a method of producing a periodically arranged line or dot layer minute pattern.

Fig. 15 is an illustration for showing a composition of an organic light emitting element having a micro-resonator structure wherein a light emitting layer has a structure of a periodically arranged dot layer pattern.

Fig. 16 is an illustration for showing a composition of an organic light emitting element having a micro-resonator structure wherein a light emitting layer has a structure of a periodically arranged layer pattern in the direction perpendicular to the substrate, in addition to the direction parallel to the substrate.

Fig. 17 is a graph showing the relation between a luminescent intensity peak ratio of emitted light and an optical length of a resonator or a periodical line type layer (optical length of a resonator or a periodical line type layer / a wave length of emitted light).

Fig. 18 is an illustration for showing a composition of an organic electro-luminescence element having a micro-resonator structure wherein a structure of a periodically arranged line layer pattern is formed at a light emitting layer.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Details of embodiments according to the present invention will be explained with reference to the drawings.

Fig. 1 shows a composition of an organic light emitting element having a micro-resonator structure, of an embodiment according to the present invention. Shaping a peripheral side face of the organic light emitting element by removing a part outside an area to be formed as a light emitting element is carried out to an intermediate position in the thickness of a transparent electrode film 103. In Fig. 1, a laminated two layer type p/n EL (Electro-Luminescence) elements composed of a light emitting layer and a hole transport layer is shown.

However, an one layer type or more than 2 layer type organic light emitting element, in which functions of the above-mentioned two organic layers are integrated into one organic layer, or shared to more than two organic layers, has been reported, and those type organic light emitting elements can be also used for the present invention.

In Fig. 1, a translucent film 102 made of titanium oxide or silicon dioxide is formed on a glass substrate 101, and a transparent electrode 103, a hole transport layer 104, a light emitting layer 105 and a metal back surface electrode 106 are layered in turn on the translucent film 102. As the above material, the material described in the above-mentioned paper presented in the transaction of the institute of electronics, information and communication engineers C-II, J77-C-II, 437 (1994), by the inventor of the present invention, etc., can be used, and other kinds of material having the property similar to that of the above material are also applicable to the present invention.

Furthermore, a feature of the present invention is that a peripheral side face of the organic thin film is shaped into such that the side face functions as a translucent reflector realized by the difference between a refraction index of the organic thin film and that of ambient substance outside the organic thin film, and light emitted in the organic thin film is reflected into the inside of the organic thin film by the side face. That is, the attenuation and the extinction of emitted light is prevented by forming the above-mentioned interval in which the thickness of the organic thin film gradually changes, as small as possible, and confining the emitted light in the organic thin film.

The light emitting layer 105 and the hole transport layer 104 are made of, for example, aluminum chelate (ALQ) and triphenyl-diamine (TAD), respectively, and their chemical structures are shown in Fig. 2. The transmittance of a dielectric translucent reflection film 102 of a 6-layer laminated film composed of titanium oxide layers and silicon dioxide layers is indicated in Fig. 3. In the region of a more than 400 nm wave length, light which is not transmitted in the translucent reflection film 102 is almost reflected by the translucent reflection film 102.

The organic light emitting element according to the present invention is produced by a cutting process and a dry etching process. In the cutting process, a sharp edge of a cutting device, made of glass, etc., is operated at a surface of a formed metal back surface electrode 106 in an organic light emitting element. The cutting process is typically illustrated in Fig. 4. An electron microscope sectional image of the light emitting element for which the cutting process is performed is shown in Fig. 5. Moreover, an electron microscope sectional image of the light emitting element for which the dry etching process is further performed is shown in Fig. 6. The etching conditions are indicated in Table 1. As shown in Fig. 5 and Fig. 6, the part outside the part designed to be left remaining, of the organic thin film,

was removed by the etching process, and a periphery side face of the remaining organic thin film part was finely shaped.

Table 1

Gas	CF ₁ (10 %) + O ₂ (90 %)
Pressure	2 Pa
RF power	200 W

In Fig. 5 and Fig. 6, mark QUARTZ indicates the glass substrate 101, mark ITO indicates the transparent electrode 103, mark TAD indicate the hole transport layer 104, mark ALQ indicates the light emitting layer 105, and mark Al:Li indicates the metal back surface electrode 106.

Furthermore, the above mentioned producing processes of an organic light emitting element have an advantage that an organic light emitting element can be produced without using chemical substance such as resist. To bring an organic EL element fully in effect, it is important to keep the high purity of the organic thin film material. Mixing of very small impurity deteriorates the performance of an organic EL element in the extreme. Moreover, since the thickness of an organic thin film is about 100 nm, and its volume is also very small, diffusion mixing of very small impurity from substance such as resist largely degrades the performance of the organic thin film. The above-mentioned producing method according to the present invention can solve this problem of impurity. Furthermore, the production cost of an organic light emitting element can be more reduced by using a cutting device exclusive to a masking pattern in comparison with a production method using resist.

The accuracy of a micro-cutting process depends on the accuracy of moving an edge of a cutter, or driving a substrate. By applying a micro-control technique used to control a stage position in STM (Scanning Tunneling Microscope) and SEM (Scanning Electron Microscope), the accuracy of a micro-cutting at a level of microns or less is possible.

Although it is desirable that the peripheral side face of an organic thin film is ideally perpendicular to the surface of the substrate, if the peripheral side face of the organic thin film, in a range of about 40 % - 90 % of the thickness of the organic thin film, is perpendicular to the surface of the substrate, light emitted in the organic thin film can be sufficiently reflected by the peripheral side face, in other words, can be confined in the organic thin film.

Figs. 7A, 7B and 7C shows sectional views of light emitting elements of which depths formed by the etching process are different from each other. Fig. 7A shows a sectional view of a light emitting elements, which is etched in its depth to the bottom surface of the layer

104, Fig. 7B shows a sectional view of a light emitting elements, which is etched in its depth to the bottom surface of the ITO film 103, and Fig. 7C shows a sectional view of a light emitting elements, which is etched in its depth to the bottom surface of the translucent reflection film 102. In selecting one of the above-mentioned three types elements, an element which is optimal to an object in using an organic light emitting element is selected by considering a production cost and the effect of light reflection by the side face. In order to etch an organic light element deeply, it is necessary to use the metal back surface electrode film of a large thickness or low etching speed type material as the electrode film, or to mount a layer of low etching speed type material on the electrode and cut the mounted layer and the electrode film together.

As shown in Fig. 8, by forming an insulation film on an organic light emitting element, further covering over the insulation film with a metal reflection film, the effect of light reflection by the side face is further improved.

Fig. 9A is a perspective view of organic light emitting elements having a three-dimensional light confinement structure, and Fig. 9B is a perspective view of an organic light emitting element having a two-dimensional light confinement structure.

Fig. 13 shows an organic thin film light emitting element having a resonator structure provided in the direction perpendicular to the thin film, and including a translucent reflection film composed of a laminated dielectric multilayer thin film. In Fig. 13, numerals 401, 402, (403A, 403B) and 404 indicate a glass substrate, a translucent reflection film of a laminated 6 layer film composed of titanium oxide layers and silicon dioxide layers, an organic light emitting thin film, and a metal back surface electrode made of Al:Li alloy. The organic light emitting thin film (403A and 403B) has a periodically arranged line type layer structure. In Fig. 13, the structure of the organic light emitting thin film (403A and 403B) is separately shown. The metal back surface electrode 404 is formed at the top of the organic light emitting thin film (403A and 403B) by a vapor deposition method, after the light emitting thin film having the periodically arranged line layer structure is formed. By irradiating the light emitting thin film with ultra-violet light, the layer is excited, and it emits visual light.

Fig. 15 is an illustration for showing a composition of an light emitting element wherein an organic light emitting thin film has a structure of a periodically arranged dot layer pattern. In a light emitting layer having a structure of a periodically arranged line layer pattern, only light proceeding to the direction perpendicular to each line is reflected. On the other hand, in a light emitting thin film having a structure of a periodically arranged dot layer pattern, light proceeding to the two direction perpendicular to each other is reflected.

Fig. 16 is an illustration for showing a composition of a light emitting element wherein an organic light emitting thin film has a structure of a periodically arranged

layer pattern in the direction perpendicular to the substrate, in addition to the direction parallel to the substrate. This structure of the organic light emitting thin film is formed by repeatedly applying a series of processes of forming an organic thin film and processing of a periodically arranged layer pattern, in the direction perpendicular to the substrate.

In Fig. 14, a minute processing of a substance, for which light sent through an optical fiber is used, is typically and conceptually illustrated. In the minute processing, light sent through an optical fiber is taken out from an aperture of the top in the fiber. If the size of the aperture is as small as 1 / 4 of a wave length of the light, usual light can not proceed out of the aperture. In this situation, light can exist only at a very small local area of the size of about 1 / 4, which is so-called a near-field, generated in the vicinity of the outside of the aperture. It has been reported in App. Phys. lett. 61, p. 142 that by moving the aperture of the top in the fiber, a substance can be minutely processed by the light at the near-field.

By forming the above-mentioned structures for confining emitted light in a light emitting thin film, a light resonator is composed in a light emitting element, and it is possible to compose such a light emitting element that a classical or quantum effect (correction of light emission enhancement due to the transition probability mechanism) due to the light confinement or the light resonance is applied to the light emitting element. Naturally, since the effect of light reflection by the side face becomes relatively larger as a surface area of a light emitting element decrease smaller, the effect of the shape in the side face according to the present invention also becomes larger.

Hereupon, it is necessary to set a distance between two light emitting elements neighboring each other to more than 1 / 4 of a wave length λ of emitted light, which the etching process were performed for, and are shown in Figs. 7A - 7C, Fig. 8 and Fig. 9A.

The reason why the distance of more than 1 / 4 of a wave length λ is necessary is because light leaking from a light emitting element reaches the positions apart from the element by 1 / 4 of λ , and leakage lights from light emitting elements neighboring each other interfere with each other.

It is well known that in many kinds of organic material, combining between molecules is generated, or decomposition or phase changes such as crystallization occur, by receiving energy such as light, heat, etc.. The above-mentioned physical or chemical changes in organic material often cause the change of a refraction index. Therefore, it is possible to embed layers having a function of a translucent reflector in an organic light emitting thin film by forming a periodically arranged line or dot layer pattern in the organic thin film at a periodical length of 1 / 4, 3 / 4, 5 / 4 and so on, of a wave length of emitted light, by making use of the change of a refraction index due to the physical or chemical change of the organic thin film. By those periodically formed layers,

light proceeding in the direction perpendicular to each line layer or each dot layer is reflected and confined.

The above-mentioned light confinement according to the present invention is effective, especially to an organic light emitting element having a resonator structure formed by providing two reflector films such as a laminated dielectric multilayer reflection film, at the top and bottom surfaces of an organic light emitting thin film.

In both of the directions parallel and perpendicular to the substrate, the largest effect of the light confinement can be obtained, if the periodic optical length which is expressed as a geometrical length \times a refraction index in material, of the embedded reflector layers in the organic thin film, is 1/4 of a wave length of emitted light. Moreover, the largest effect of the light confinement can be obtained, if the depth of the resonator is 1/4 or 1/2 of a wave length. It depends on that the total amount of a phase shift due to light reflection by the reflector films is one or a half of a wave length, which depth of 1/4 or 1/2 of a wave length brings the largest effect. A periodic length or a depth larger by 1/2 of a wave length than the above-mentioned optimal periodic length or depth can satisfy the light confinement or resonance conditions.

There is actually the upper limit to an effective periodic length or a depth of a resonator, which is brought by the unevenness of surfaces or boundary faces in the resonator and the periodically arranged layers in the organic light emitting thin film. That is, as a periodic length or a depth of a resonator increases, a quantum effect such as a micro-resonator effect decreases, and the strength of the resonance becomes weak, which is caused by the unevenness of surfaces in the resonator. Fig. 17 is a graph showing the relation between a relative peak strength of emitted light and a relative optical length of a resonator or a line type layer. As seen in Fig. 17, it is necessary to compose the optical length or depth of less than 10 times of a wave length in order to obtain more than 10 % effect related with the peak strength.

An organic light emitting thin film having a periodically arranged line or dot layer structure functions as a translucent reflector, and reflects light with a definite ratio into the inside of the thin film.

Fig. 10A shows a luminescence panel using organic EL elements which have the three-dimensional light confinement structure. Each of the organic EL elements have the same composition as that of the organic light emitting element shown in Fig. 1. Numerals 101, 101A and 102, indicate two glass substrates, and a translucent reflection film of a laminated 6-layer film made of titanium oxide and silicon dioxide, respectively. Moreover, numerals 103, 104, 105 and 106, indicate transparent electrodes made of indium-tin oxide (ITO), which have the thickness of 200 nm, hole transport layers made of triphenyl-diamine (TAD), which have the thickness of 50 nm, light emitting layers made of alumin-

um chelate (ALQ), which have the thickness of 50 nm, metal back surface electrodes made of aluminum-lithium alloy (allele), which have the thickness of 200 nm, respectively. The two substrates 101 and 101A are adhered to each other with adhesive 302, and the light emitting elements are contained in a space 301 between the two substrates 101 and 101A. Dry nitrogen gas is enclosed in the space 301.

As shown in Fig. 10B, by using the transparent front surface electrodes 103 and the metal back surface electrodes 303, matrix type electrodes are composed, and light emitting parts are selected. Projecting parts 304 which are made of soft metal such as In formed on the electrodes 303, and the transparent front surface electrodes 106 and the metal back surface electrodes 303 are pressurized and connected to each other via the projecting parts 304. In this composition, an insulation part is necessary to prevent the electrodes 103 from contacting to the electrodes 303 at the places other than luminescence pixel parts.

The number of organic light emitting elements arranged at each of element areas, the electrodes 303 and the electrodes 103 intersecting each other at the element areas as shown in Fig. 10B, is not restricted to one, but more than one organic light emitting elements can be arranged at each of the element areas. In an embodiment shown in Fig. 10C, two light emitting elements are arranged at each of the element areas.

Fig. 18 is a sectional view of an organic light emitting element of an embodiment according to the present invention. In the organic light emitting element shown in Fig. 18, a laminated 6-layer thin film composed of titanium oxide layers (the thickness of each layer is 54 nm) and silicon dioxide layers (the thickness of each layer is 86 nm) is used as a dielectric translucent reflection film. Moreover, in Fig. 18, the chemical structure of polyacetylene derivative is shown, which is used for an organic light emitting layer. The refraction index of a polyacetylene film can be changed by growing the principal chain of carbon bonding in polyacetylene derivative using a photoreaction processing. The spectrum of light emitted by polyacetylene derivative can be changed by changing the kinds of molecules which are combined to branches of the polyacetylene derivative. The thickness of the metal back surface electrode 404 is 200 nm. Moreover, numeral 405 indicates a transparent electrode made of ITO, of which thickness is 200 nm. By applying the voltage between the electrodes 404 and 405, electrons and holes are injected into the light emitting layer, and those are recombined, further excite organic material of the layer. Thus, light is emitted from the excited organic material.

Although an example of an EL (electro-luminescence) element of an one layer type element structure is explained in Fig. 18, a report of a two layer type or more than 2 layer type EL element, in which functions of the above-mentioned one layer type element are shared to two or more organic layers, has been presented, and

those type EL elements are also applicable to the present invention.

In accordance with the present invention, since light emitted in a light emitting thin film is reflected into the inside of the layer by a peripheral side face of the shape formed according to the present invention at a definite ratio of the quantity of light reflected by the side face to the quantity of light reaching the side face, the lost quantity of emitted light can be reduced, and the total quantity of effective light output from the front surface of the light emitting thin film can be increased. That is, the ratio of the quantity of light output from a light emitting element to the quantity of energy input into the light emitting element is improved. By forming the above-mentioned structures for confining emitted light in a light emitting film, it is possible to compose such an organic light emitting element that a light resonator is composed, and a classical or quantum effect (correction of light emission enhancement due to the transition probability mechanism) due to the light confinement or the light resonance can be applied to the light emitting element.

Claims

1. An organic light emitting element including an organic thin film (105; 403A, 403B) formed on a substrate (101; 401) wherein a peripheral side face of said organic thin film has such a sectional shape that emitted light is reflected by said side surface. 30
2. An organic light emitting element including an organic thin film (105; 403A, 403B) formed on a substrate (101; 401), wherein the difference between a refraction index of said organic thin film (105; 403A, 403B) and that of ambient substance outside said organic thin film (105; 403A, 403B) is set to such that emitted light is confined in said organic thin film by a peripheral side face of said organic thin film. 35
3. An organic light emitting element including an organic thin film (105; 403A, 403B) formed on a substrate (101; 401), wherein a peripheral side surface of said organic thin film stands, in a range of 50 % - 90 % of the thickness of said organic thin film, perpendicular to said substrate. 40
4. An organic light emitting element including a transparent film, a transparent electrode (103; 405), a light emitting layer (105; 403A, 403B) and a metal electrode (106; 303; 404), which are layered, wherein a peripheral side face of a layer part composed of said light emitting layer (105; 403A, 403B) and said metal electrode (106; 303; 404) stands, in a range of 50 % - 90 % of the total thickness of said part, perpendicular to said substrate. 45
5. An organic light emitting element including a transparent electrode (103), a light emitting layer (105) and a metal electrode (106), which are layered, wherein a plurality of layer parts, each of said layer parts including said light emitting layer (105) and said metal electrode (106), are separately arranged in a plane parallel to said substrate, respectively, and a distance between each two parts neighboring each other in said parts is larger than 1/4 of a wavelength of light emitted in said light emitting element. 5
6. An organic light emitting element, comprising:
a translucent reflector (402) made of one of a laminated dielectric film and a translucent metal film, formed at the front side of an organic light emitting film (403A, 403B), an optical resonator being composed between said reflector (402) and an upper electrode (404) on said organic light emitting film (403A, 403B) in the direction perpendicular to said organic light emitting film (403A, 403B); wherein a side peripheral face of said organic light emitting film (403A, 403B) has such a sectional shape that emitted light is reflected by said side surfaces. 20
7. An organic light emitting element comprising:
a translucent reflector (402) made of one of a laminated dielectric film and a translucent metal film, formed at the front side of an organic light emitting film (403A, 403B), an optical resonator being composed between said reflector (402) and an upper electrode (404) on said organic light emitting film (403A, 403B) in the direction perpendicular to said organic light emitting film; wherein the difference between a refraction index of said organic light emitting film (403A, 403B) and that of ambient substance outside said organic light film (403A, 403B) is set to such that emitted light is confined in said organic light emitting film by a peripheral side face of said organic light emitting film (403A, 403B). 30
8. An organic light emitting element, comprising:
a translucent reflector (402) made of one of a laminated dielectric film and a translucent metal film, formed at the front side of an organic light emitting film (403A, 403B), an optical resonator being composed between said reflector (402) and an upper electrode (404) formed on said organic light emitting film (403A, 403B) in the direction perpendicular to said organic light emitting film; 50
- 55

wherein a peripheral side surface of said organic light emitting film stands, in a range of 50 % - 90 % of the thickness of said organic light emitting film, perpendicular to said substrate.

9. An organic light emitting element, comprising:

a multilayer of a translucent reflector film (402), a transparent electrode (405), a light emitting layer (403A, 403B) and a metal electrode (404);

wherein an optical resonator is composed between said translucent reflector film (402) and said metal electrode (404) formed on said light emitting layer (403A, 403B) in the direction perpendicular to said organic light emitting layer (403A, 403B), and a peripheral side face of a layer part composed of said light emitting layer (403A, 403B) and said metal electrode (404), in a range of 50 % - 90 % of the total thickness of said layer part, stands perpendicular to said substrate of said light emitting element.

10. An organic light emitting element, comprising:

a multilayer of a translucent reflector film (102), a light emitting layer (105) and a metal electrode (106);

wherein an optical resonator is composed between said translucent reflector film (102) and said metal electrode (106) on said light emitting layer (105) in the direction perpendicular to said organic light emitting layer (105), and a plurality of layer parts, each of said layer parts including said light emitting layer (105) and said metal electrode (106), are separately arranged in a plane parallel to said substrate (101) respectively, and a distance between each pair of layer parts neighboring each other in said parts is larger than 1/4 of a wave length of light emitted in said light emitting element.

11. A method of producing an organic light emitting element including an organic thin film (105; 403A, 403B), said method comprising the steps of:

forming a metal thin film (106; 404) on said organic thin film (105; 403A, 403B);

forming a mask of a desired pattern by physically or mechanically removing parts of said metal thin film (106; 404); and

applying dry etching processing to said organic thin film with said mask.

12. A method according to claim 11, further including the step of utilizing said mask remaining on said etched organic thin film as electrodes.

5 13. An organic light emitting element having a resonator structure in the direction perpendicular to a substrate of said light emitting element, said resonator structure being composed by sandwiching an organic thin film in said light emitting element between reflectors, said organic light emitting element comprising:

one of a periodical line layer structure and a periodical dot layer structure in said organic thin film and a part of thin films formed on the top face and bottom faces of the organic thin film, in which line layers or dot layers are periodically arranged in parallel to said organic thin film, wherein each two line layers neighboring each other or each two dot layers neighboring each other have different material compositions or material structures, and a period of said layer arrangement, which is represented by an optical length expressed as a geometrical length X a refraction index in material of each layer, is substantially 1/4 of a wave length in each layer, of light emitted in said organic thin film.

30 14. An organic light emitting element according to claim 13, wherein said period is $(1 + 2m)/4$ of a wave length of light in each layer, where m is an integer taking a value in a range 1 to 19.

35 15. An organic light emitting element according to claim 14, wherein said periodical layer structure is formed by using a near-field light.

40 16. An organic light emitting element according to claim 14, further including a translucent reflector (402) and a transparent conductive film (405), composed of dielectric multilayer films, wherein said organic thin film (403A, 403B) emits light by applying voltage to said organic thin film (403A, 403B).

45 17. An organic light emitting element according to claim 14, wherein said periodical structure composes one of two-dimensional and three-dimensional resonators by making use of light reflection due to different refraction indexes in each two layers neighboring each other.

FIG.1

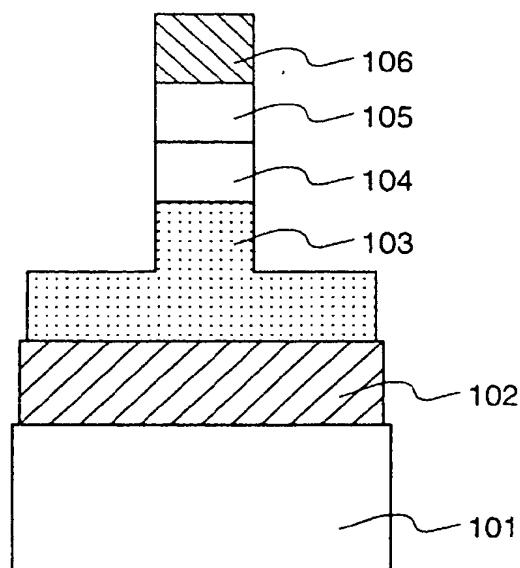


FIG.2

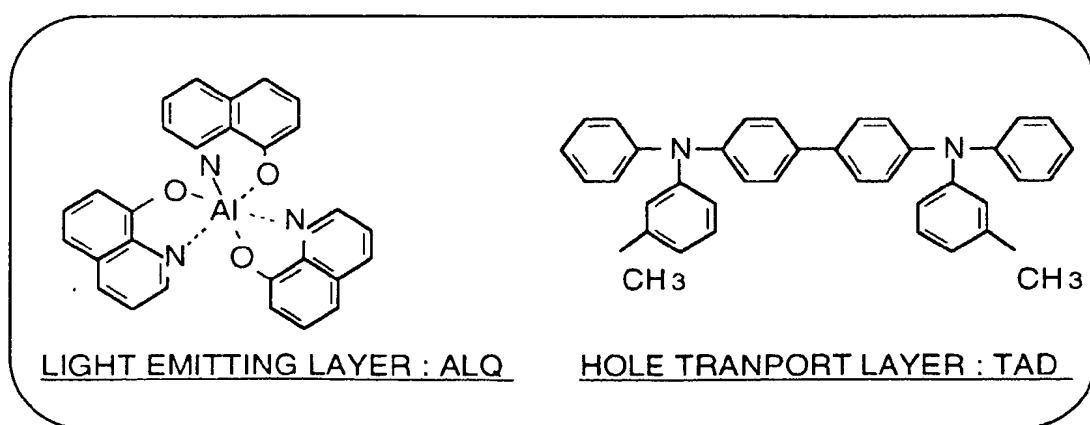


FIG.3

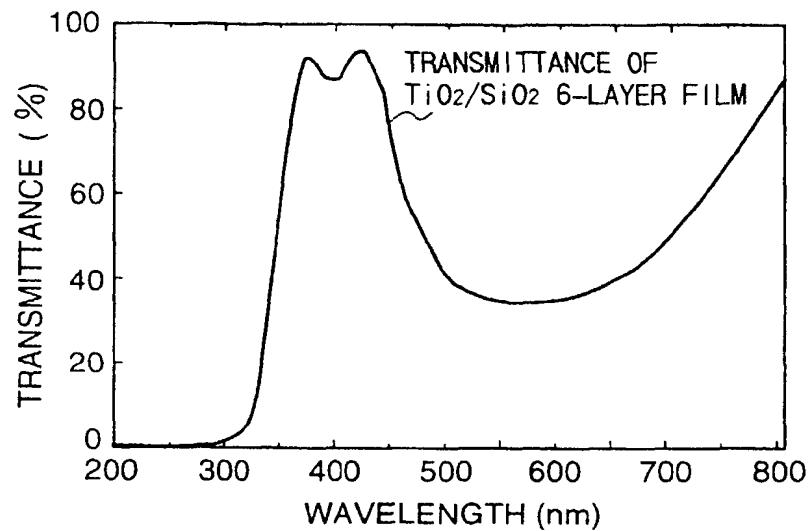


FIG.4

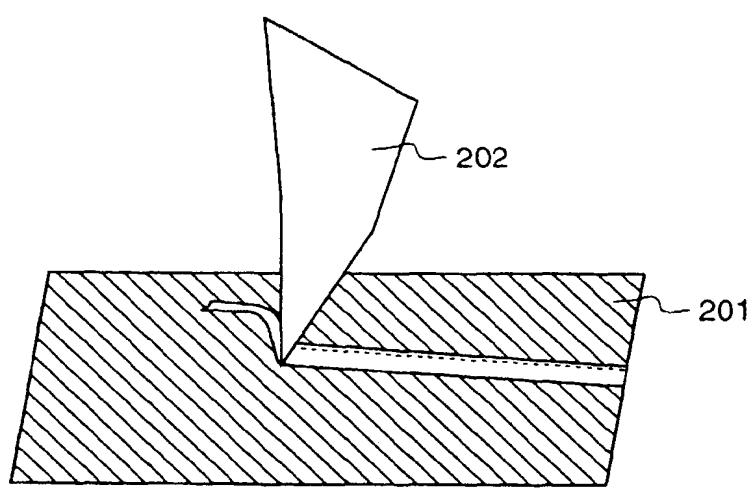


FIG.5



FIG.6



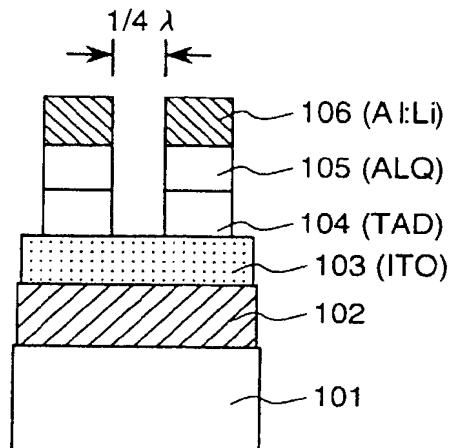
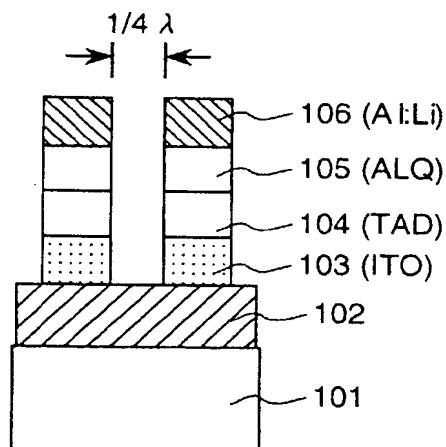
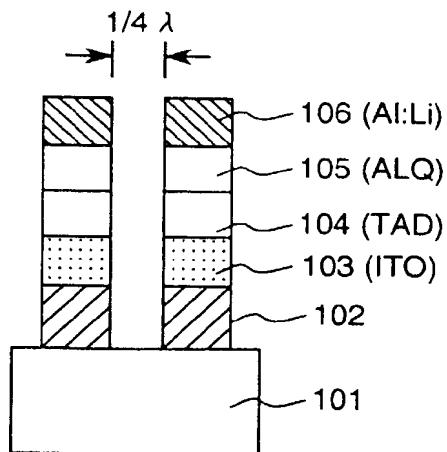
FIG. 7A*FIG. 7B**FIG. 7C*

FIG.8

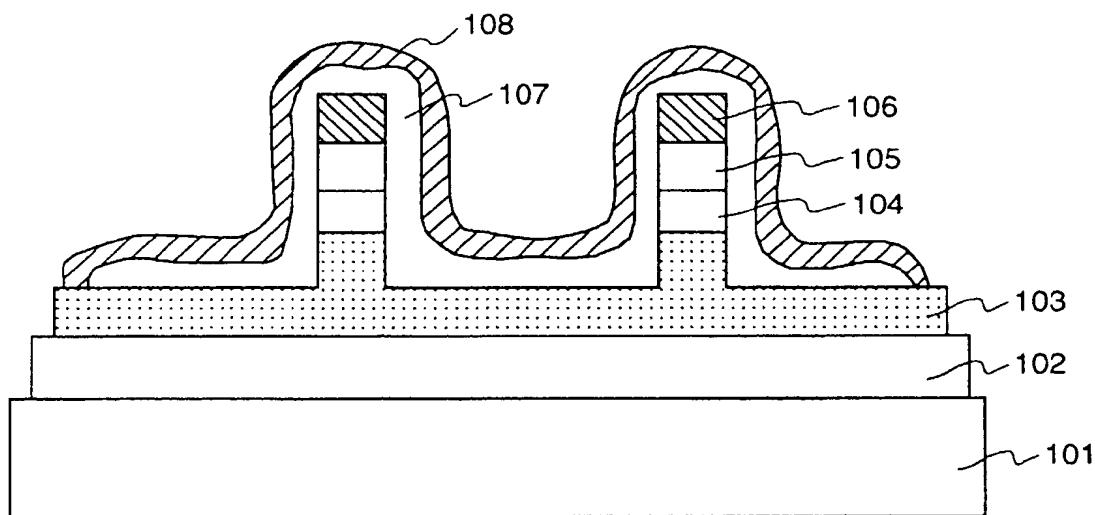


FIG.9A

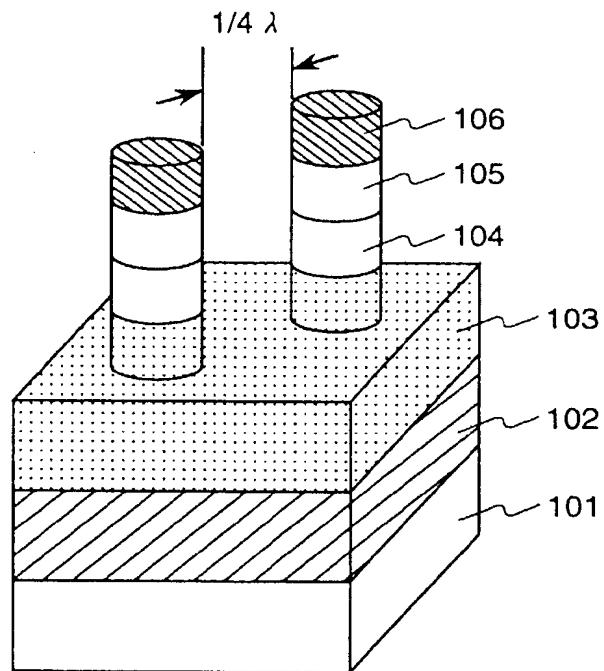


FIG.9B

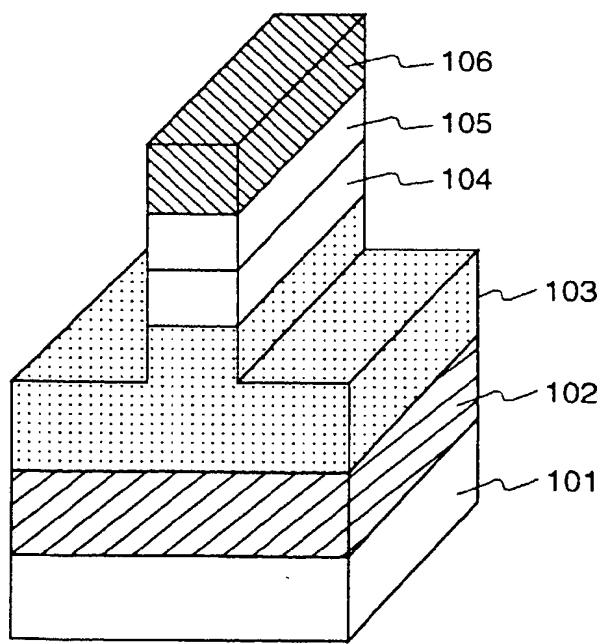


FIG. 10A

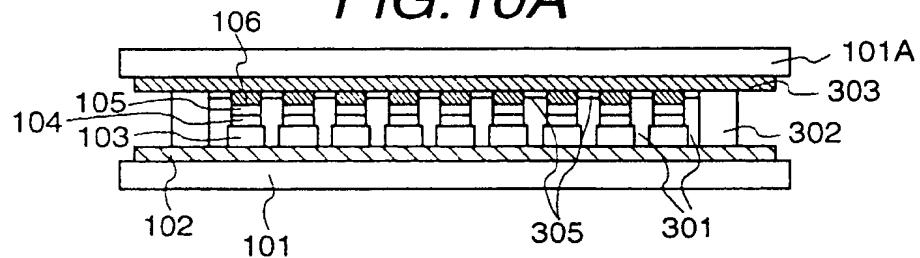


FIG. 10B

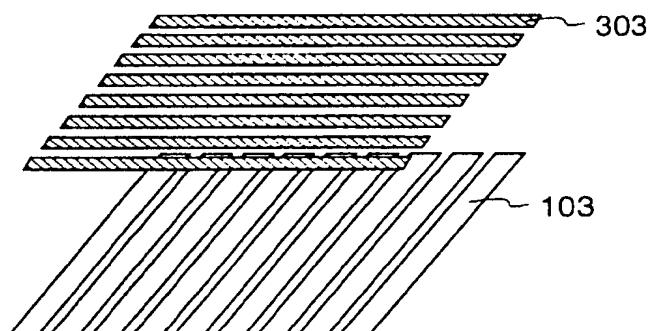


FIG. 10C

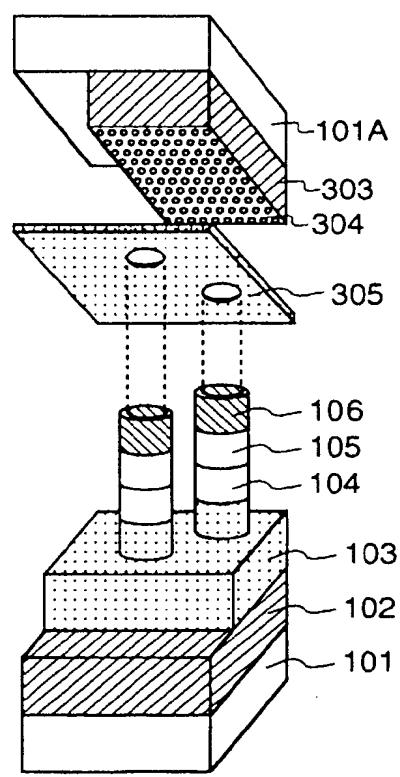


FIG. 11

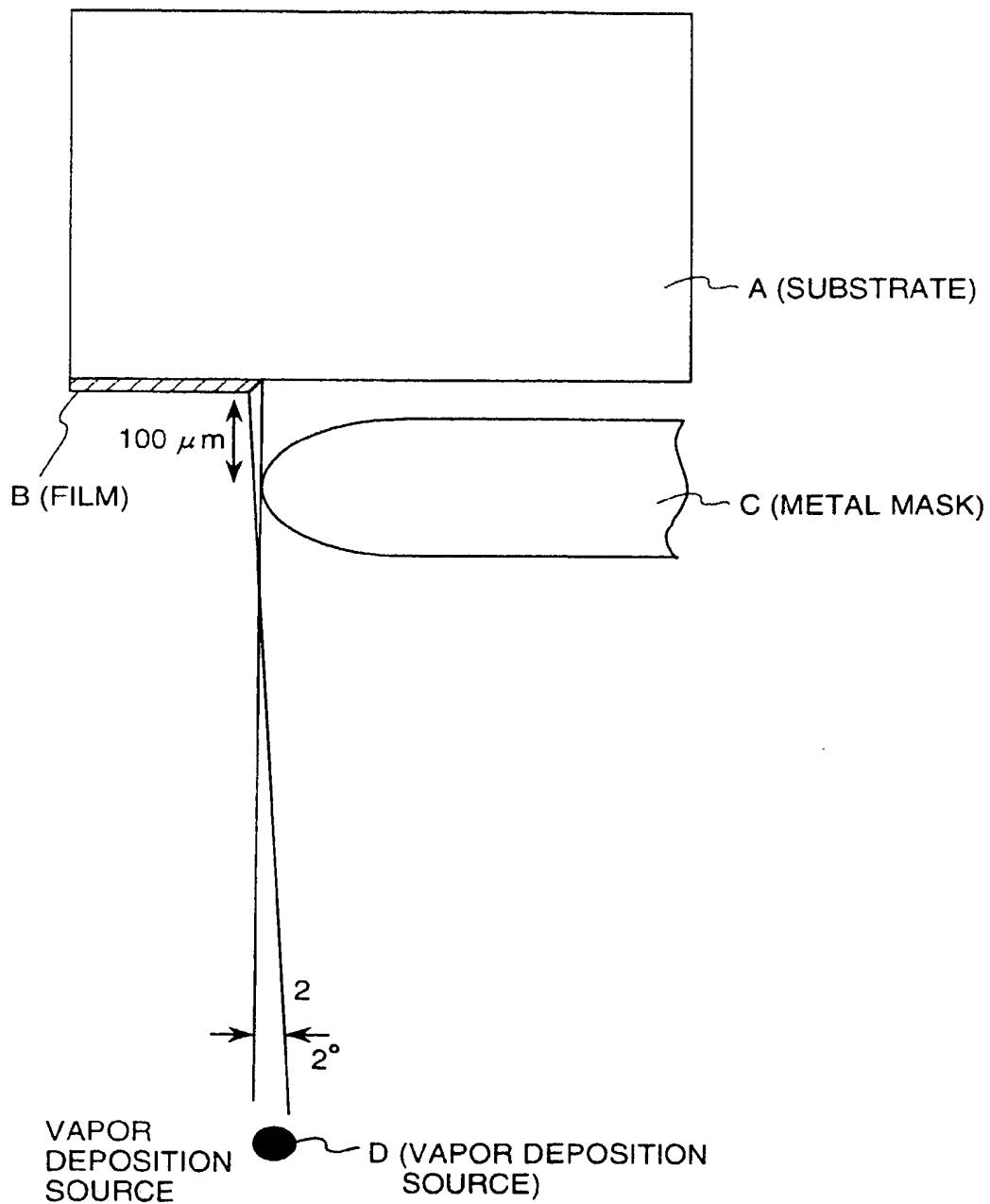


FIG. 12

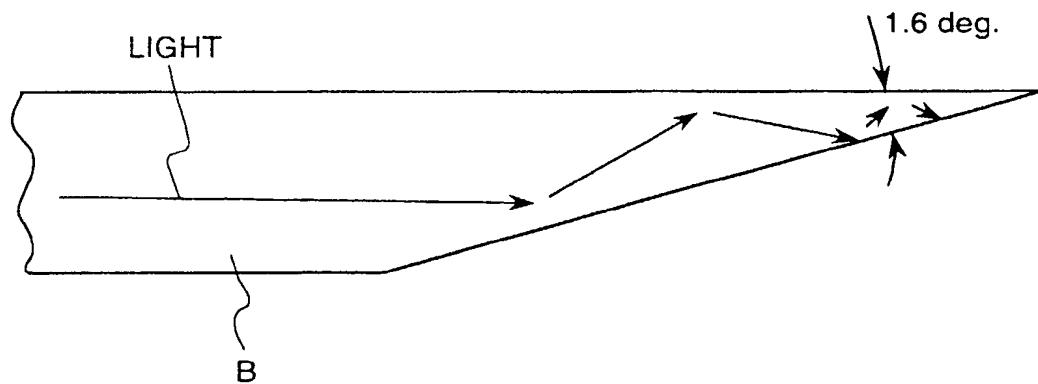


FIG. 13

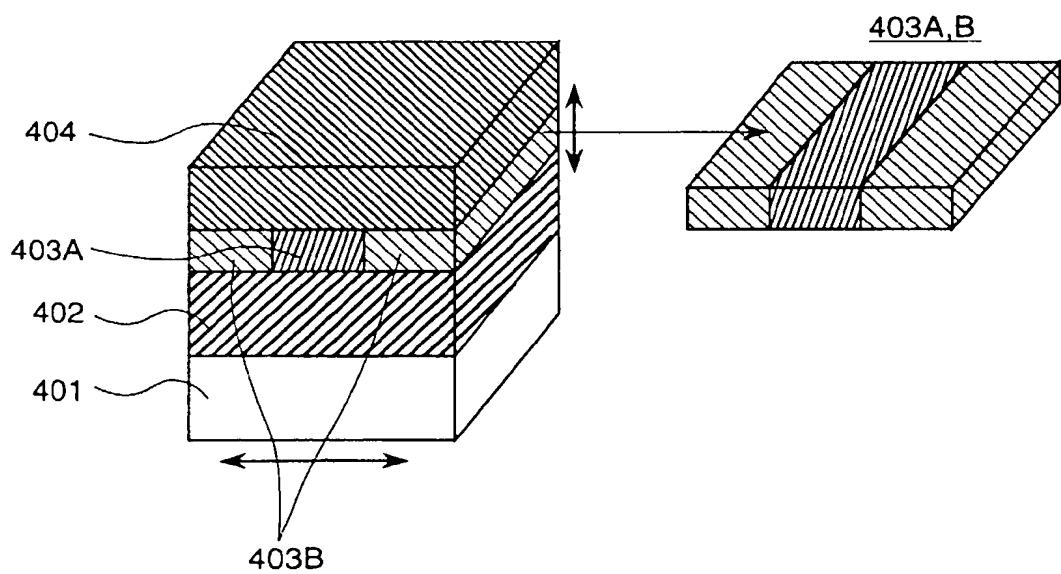


FIG. 14

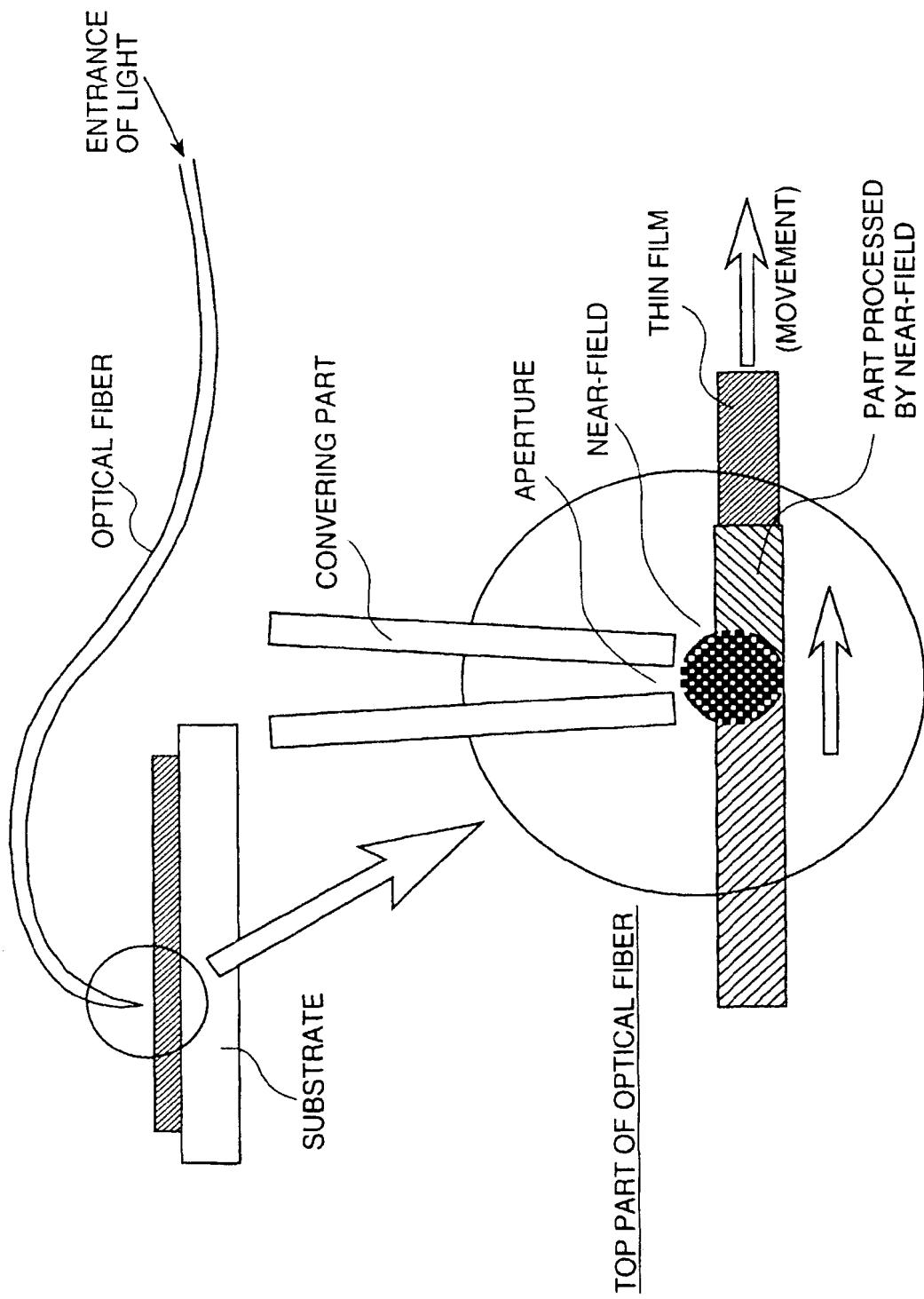


FIG. 15

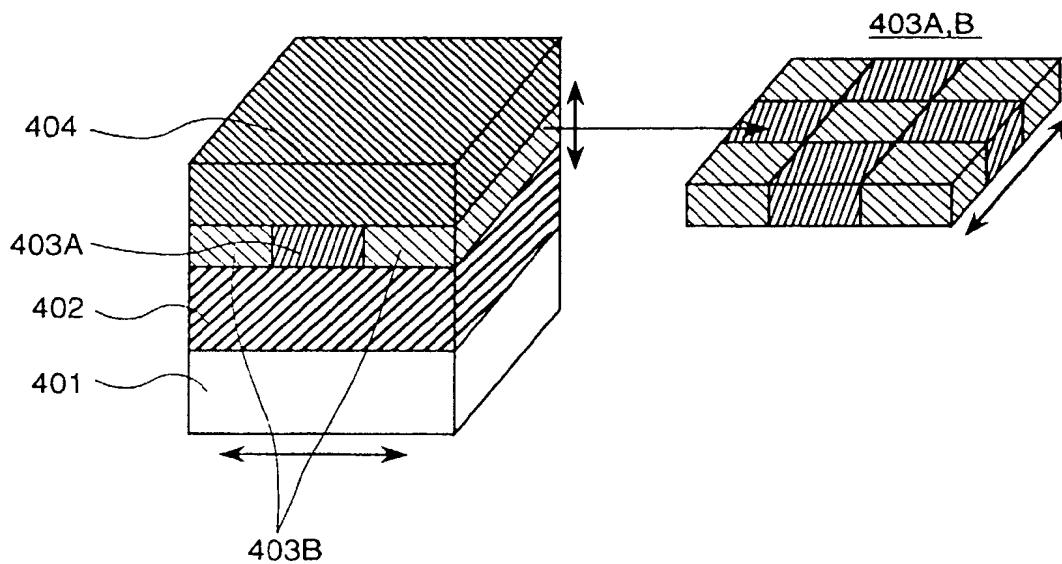


FIG. 16

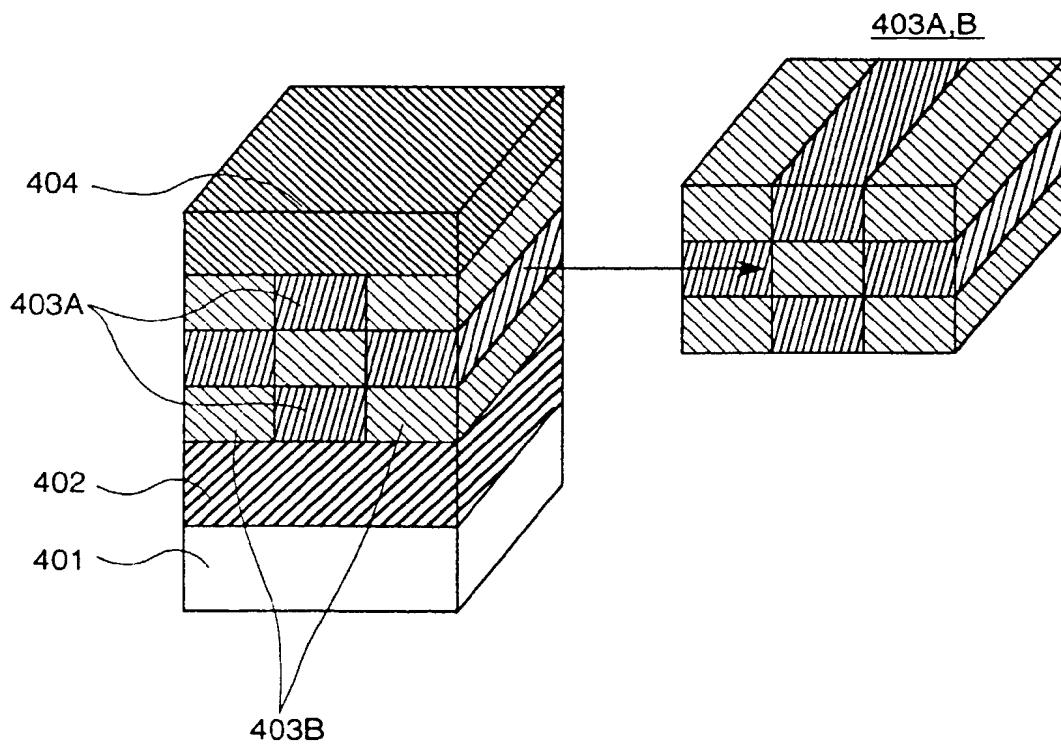


FIG. 17

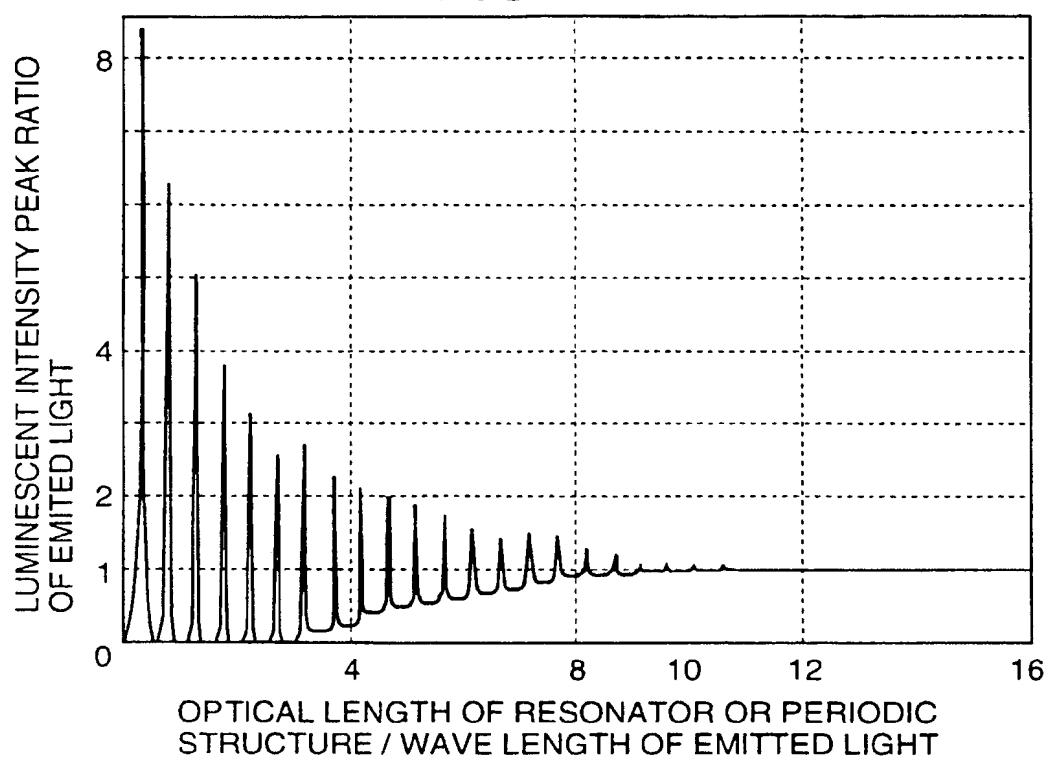
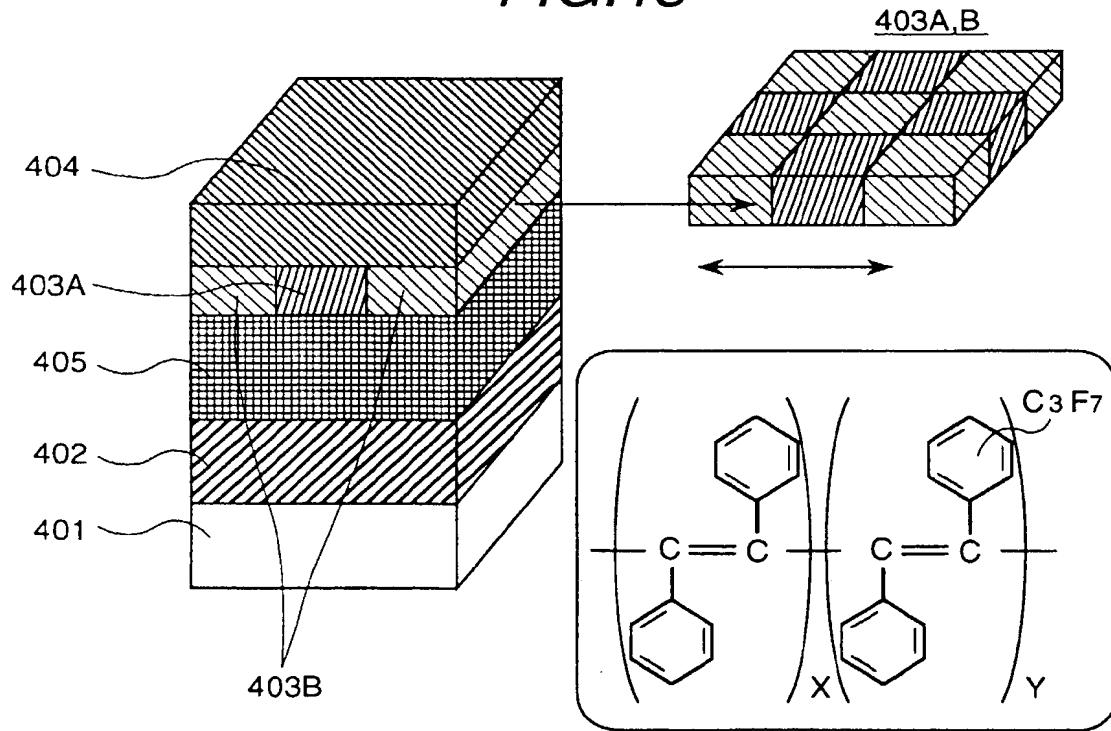


FIG. 18



**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.

THIS PAGE BLANK (USPTO)